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(54) Abstract Title
Marine counter-rotating shaft drive mechanism

(57) A counter rotating shaft drive mechanism for a boat comprises an engine gearbox output shaft coupling 2, a differential arrangement which creates counter-rotating outputs in a dual output shaft arrangement and comprises a housing 1 and removable maintenance plates 4, means (10, Fig 2) for arresting rotation of the differential housing and a coupling between the shaft arrangement and a twin propeller arrangement. A single drive gear 8 may be used to drive the output shaft arrangement which may comprise a pair of concentrically arranged shafts 5 and 9 which rotate in opposite directions. The inner and outer shafts may have rubbing pads (13, Fig 3) arranged between them, while the shaft arrangement may operate as a self-lubricating sealed unit. The housing, maintenance plates, and shafts may be manufactured from a metallic material, a plastic polymer or a carbon composite.

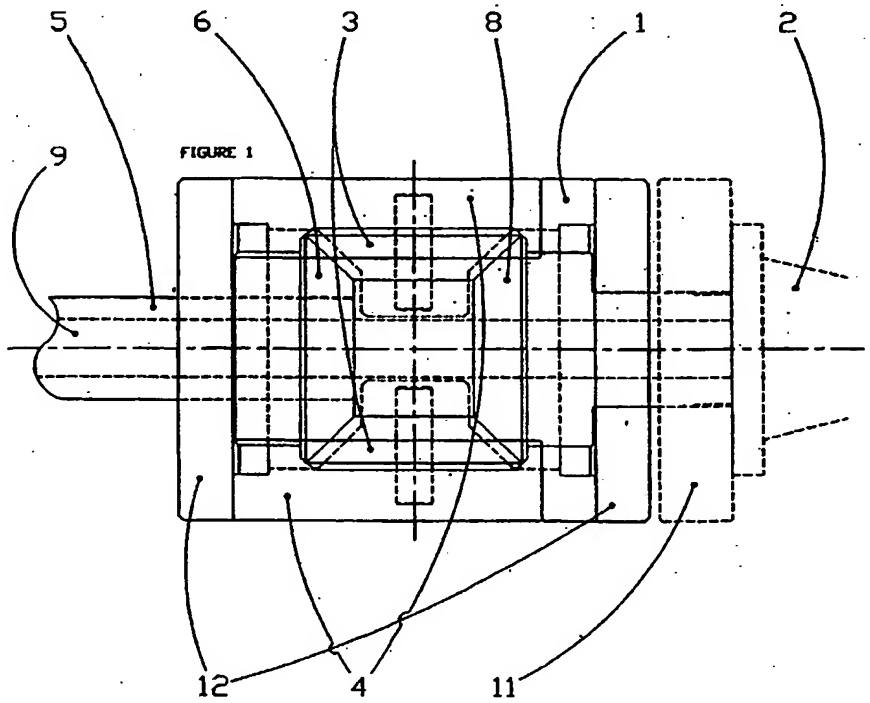

FIGURE 1

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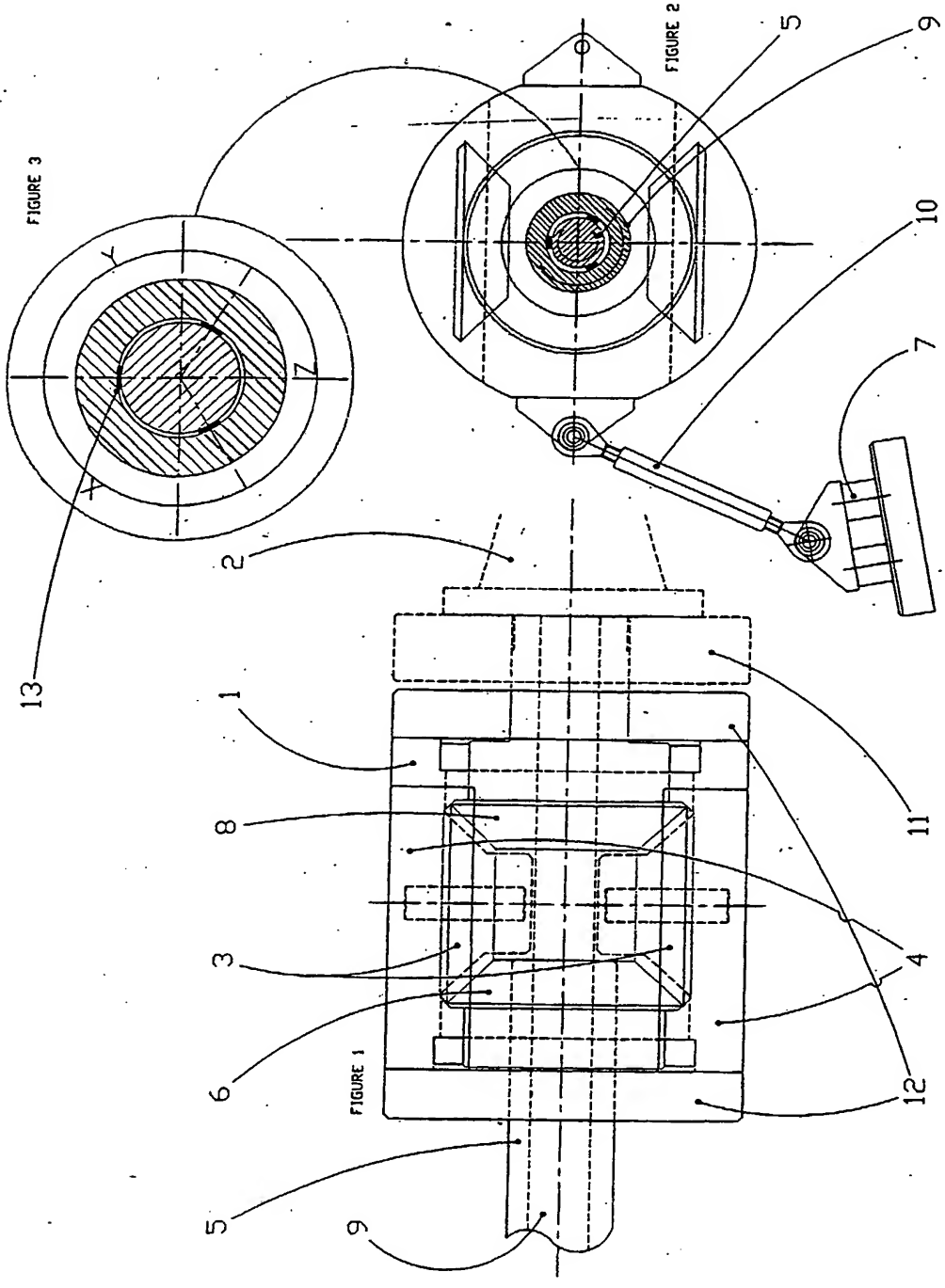


FIGURE 1

FIGURE 2

FIGURE 3

COUNTER-ROTATING SHAFT DRIVE MECHANISM

This invention relates to a Counter-Rotating Shaft Drive Mechanism.

Counter-rotating propellers eliminate waste. In this type of installation, two propellers are positioned one immediately ahead of the other on the same shaft line, but rotating in opposite directions. The rotational energy imparted to the water by the forward of the two propellers is cancelled out by the opposite rotation of the rearward propeller. The slipstream from counter-rotating propellers is almost smooth and straight, with little twist. When a single propeller accelerates water into itself from ahead and expels it astern, it generates thrust like a jet engine. Unfortunately, a significant percentage of the power delivered to the propeller also goes to twisting the water around, creating the helically shaped propeller wake. This energy is exhausted and does nothing in providing propulsion, or drive; it is, simply, wasted. Counter-rotating propellers dramatically reduce this waste effect and are 10 to 30 percent, dependant on configuration, more efficient than standard, single propellers.

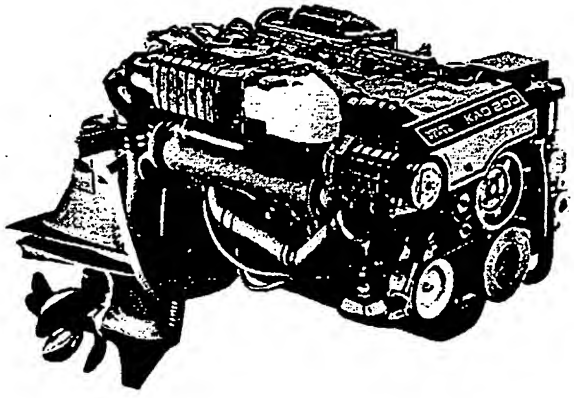
As a direct result of improved efficiency, this counter-rotating propeller arrangement offers improved thrust, handling, fuel efficiency and smoothness of operation over a single propeller.

This invention relates to a counter-rotating shaft drive application. For boat builders – the main, but not sole, target for this application -- the decision between shaft drives or sterndrives as a drive train is a dilemma.

Shaft drives are more conventional, and in the simplest sense use a shaft to transmit power from the engine's gearbox output shaft through a seal in the boat's hull to the propeller. This propeller sits forward of the steering gear. With shaft drives, engines are typically mounted towards the centre of the boat, although rearward mounted applications using a 'Z' drive arrangement are in use, and separate stern gear provides steerage.

Sterndrives, on the other hand, essentially combine the engine's gearbox and propeller running gear in a single unit, known as a 'sterndrive'. With this installation, engines are mounted at the stern of the boat and there is no separate propeller shaft arrangement. It is normal for the sterndrives to vector (turn) in order to provide steerage. Sterndrive applications are less costly as a lower power engine can be used due to increased efficiency of propulsion.

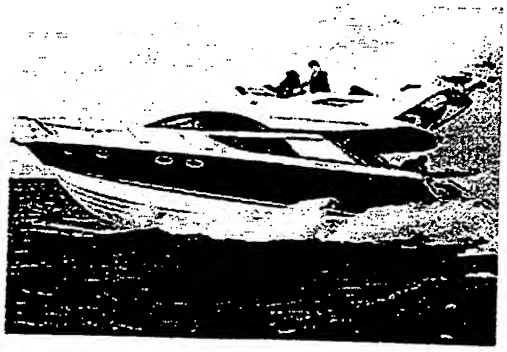
A typical sterndrive application where the engine's gearbox and propeller drive effectively combine as a single unit



For boat builders with an overall craft length of below 40 ft, the choice of power train is relatively easy – diesel engines coupled to sterndrives can provide the necessary thrust to achieve the 30-knot holy grail that today's market demands. Above 40 ft, the choice is also clear – the 300 horsepower ceiling imposed by the mechanical limitations of current sterndrives dictates a move towards shaft drives since more power is required to achieve the magic 30 knots. But between 35 ft and 45 ft, the current trend is shifting towards sterndrives because the boat builder does not have to contend with exhausts, steering gear, P-brackets, propeller shafts and alignment issues. Sterndrives are easier and cheaper to install and are inherently more power efficient than a conventional shaft drive propeller because, compared with a streamlined stern drive, the drag generated by the propeller shafts, rudders and P-brackets is significant. This all helps in achieving the magic 30 knots. However, the British boat-buying public are remarkably pro shaft drives, favouring their inherent durability.

High-power sterndrives equipped with counter-rotating propellers are commercially available. The mechanical construction of sterndrives makes for a readily adaptable counter-rotating installation due to short shaft lengths and close-quarter gearing. The inherent drawback of this type of arrangement is complexity, and general vulnerability given that the bulk of the drive gear is exposed under the waterline at the stern of the craft. Shaft drives, on the other hand, are by their nature more durable.

According to the present invention, titled Counter-Rotating Shaft Drive Mechanism, there is provided a methodology of combining sterndrive performance with shaft drive installations. The invention provides a method of creating counter-rotating output from a single input and is designed to be both retrofitable and factory fit.



Sterndrives will not endure neglect as well as shaft drives and do not offer the same lateral grip on water. Whilst sterndrives offer boats increased manoeuvrability due to their vectoring (turning of the sterndrive with the helm wheel), it is this vectoring that makes sterndrive-equipped boats heel more in turns because part of the thrust produced by the vectored drives is trying to turn the boat over. There remain many merits, therefore, to shaft drives.

The Counter-Rotating Shaft Drive is designed to bring the thrust and efficiency of sterndrives to shaft drive boats with the added benefit of increased durability, reliability and stability over sterndrives. Overall, a significant performance gain for conventional shaft drive installations is the end result. Sterndrives are not retrofitable to shaft drive boats. The Counter-Rotating Shaft Drive has been designed to be both retrofitable, and factory fit.

Technical Features

According to the present invention, there is provided a Counter-Rotating Shaft Drive Mechanism comprising: an engine gearbox output shaft coupling; differential arrangement creating counter-rotating outputs in the form of a housing with removable side and end plates and internal drive train; a combined, dual shaft arrangement allowing for counter rotation; and a coupling to a twin propeller arrangement.

A specific embodiment of the invention will now be described by way of an example with reference to the accompanying drawing in which:

Figure 1 shows a schematic of the arrangement, side-on view

Figure 2 shows an end-on view of Figure 1

Figure 3 shows the principle of the counter-rotating shaft's rubbing pad arrangement.

Figure 1 and 2

Referring to the drawing Figure 1, the Counter-Rotating Drive Shaft Mechanism comprises a differential housing 1 linked to, but not mechanically fixed to, the gearbox output shaft 2. To provide flexibility of installation, a range of adapters 11 may be inserted between 1 and 2.

The differential housing 1 comprises a machined body designed to carry opposing bevel idler gears (3). The differential housing 1 is arrested through the use of anti-rotating tie bars 10. This enables the internal power train to operate, driven by the engine's gearbox output shaft 2. Initial shock loads caused by engagement of the gearbox output shaft are absorbed by rubber mountings 7. Two side plates 4, which are removable, are used to retain the opposing idler bevel gears 3 in place. The bevel gears 3 are driven by a single bevel idler gear 8 secured to the engine's gearbox output shaft through the use of a spline and key or similar. The driver bevel gear 8 and idler bevel gears 3 are used to drive the outer propeller shaft 5 through a driven bevel gear 6. The bevel gear set is designed to use either straight or helical gear teeth for efficient power transfer. The gearing arrangement 8,3,6 reverses the direction of the input drive from the engine's gearbox output shaft 2 thereby providing counter rotation. The gearing arrangement is maintained through removal of the side plates 4 and end plates 12.

The driven bevel gear 6 is attached mechanically to the outer output shaft 5 through the use of a spline and key or similar.

The inner propeller shaft 9 is secured mechanically to the driving gear 8. This mechanical fixing dictates that the inner propeller shaft 9 is driven in the same direction as the engine's gearbox output shaft 2. This direction of drive is opposite to that of the outer propeller shaft 5 and counter rotation is achieved. Mechanical securing of the inner propeller shaft to the driver bevel gear 8 is achieved through a

spline and key or similar. The differential arrangement shown in Figure 1 runs as a sealed unit. The invention has been scoped to manufacture the differential housing 1, side plates 4, end plates 12, outer propeller shaft 5 and inner propeller shaft 9 from either a metallic material or that of carbon composite. Choice of material used within the construction of the Counter Rotating Shaft Drive Mechanism is dependent on application. Larger installations will benefit from the weight saving properties of carbon composite.

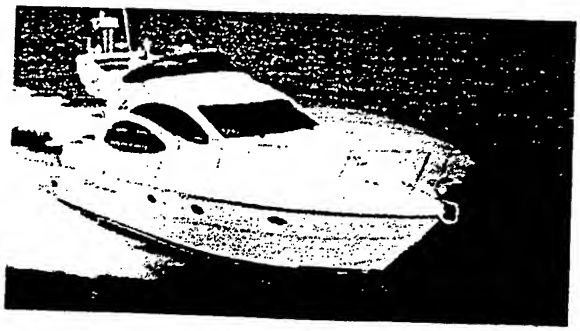
The outer propeller shaft 5 is comparable in size to the recipient craft manufacturer's original propeller shaft specification. The inner propeller shaft's 9 rotation is counter to the outer shaft 5.

To ensure optimum performance, the counter-rotating shaft arrangement makes use of bearings at either end and bespoke rubbing pads 13 positioned along the shaft's length. A key feature of these pads is their irregular spacing. This prevents 'bounce' and vibration of the inner shaft. The number of rubbing pads 13 is dependent on the length of the outer propeller shaft 5. The rubbing pads are manufactured from a self-lubricating material. The shaft arrangement is sealed either end through the use of dual seals at each end.

The invention has been scoped to adopt a propeller arrangement involving a propeller of smaller diameter and more blades behind a propeller of larger diameter and fewer blades. This is because the rearward propeller is working in a faster water flow than the forward propeller and, as a result, it must have a smaller diameter and steeper pitch. Both propellers are designed to absorb the same horsepower – hence the additional blade on the rearward propeller.

Because of the additional blades in total, a counter-rotating propeller system has more blade area and therefore lower blade loading than a comparable single propeller at the same horsepower. This will reduce cavitation (bubbles of partial vacuum caused by excessive propeller speed or loading) problems, and offer a marked improvement in vibration.

The Counter-Rotating Shaft Drive is designed to bring the thrust and efficiency of sterndrives to shaft drive boats with the added benefit of increased durability, reliability and stability over sterndrives. The Counter-Rotating Shaft Drive Mechanism has been designed to be both retrofitable, and factory fit.



CLAIMS

1 A Counter-Rotating Shaft Drive Mechanism comprising: an engine gearbox output shaft coupling; differential arrangement creating counter-rotating outputs in the form of a housing and removable maintenance plates; a combined, dual shaft arrangement allowing for counter rotation; a method of arresting the differential housing, and a coupling to a twin propeller arrangement.

2 A Counter-Rotating Shaft Drive Mechanism as claimed in Claim 1 wherein a single drive gear is used to rotate two separate propeller shafts in opposing directions.

3 A Counter-Rotating Shaft Drive Mechanism as claimed in Claim 1 or Claim 2 wherein a single drive gear is provided as the input to the differential housing.

4 A Counter-Rotating Shaft Drive Mechanism as Claimed in Claim 1, 2 or 3 wherein two drive shafts operate on the same shaft line, but rotate in opposite directions.

5 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein the drive train is maintainable through removable maintenance plates.

6 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein self-lubricating rubbing pads are used to support the inner shaft within the outer shaft.

7 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein the dual shaft arrangement is provided with a least one set of rubbing pads.

8 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein the, or each, rubbing pad set is spaced unevenly around the circumference of the inner shaft to provide smoother counter-rotating motion between the two shafts.

9 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein the dual shaft arrangement operates as a self-lubricating sealed unit.

10 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein the differential housing, maintenance plates, outer propeller shaft and inner propeller shaft are manufactured from either a metallic material, plastic polymer or carbon composite.

11 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein the dual, counter-rotating, drive shaft arrangement is designed for water and contaminant exclusion.

12 A Counter-Rotating Shaft Drive Mechanism as claimed in any preceding claim wherein the differential housing is held between the gearbox output flange and drive shafts.

13 A Counter-Rotating Shaft Drive Mechanism substantially as described herein with reference to figures 1-3 of the accompanying drawing.

INVESTOR IN PEOPLE

Application No: GB 0204058.2
Claims searched: 1 to 13

Examiner: Richard Collins
Date of search: 12 March 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): B7V VBH.

Int Cl (Ed.7): B63H 5/10, 23/00, 23/02, 23/06, 23/34.

Other: Online EPODOC, JAPIO, WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,Y	EP 0418599 A1	(FUJITA) see figure 1 and related descritpion.	X:1,2,4,10-12 Y:6-9
Y	US 5419724 A	(WYLAND) see lubricated rubbing strips 3b' in figure1b.	6-9
X,Y	US 4792314 A	(McCORMICK) see figures 1 to 3 and related descritpion.	X:1-5,10-12 Y:6-9
X,Y	US 4642059 A	(NOHARA) see figures 2 and 3 and related description.	X:1-5,10-12 Y:6-9

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.